Introduction to Energy

2002 Facts at a Glance

U.S. Energy Production:	70.9Q*	
Renewable	5.9 Q	8.3%
Nonrenewable	65.0 Q	91.7%
U.S. Energy Consumption:	97.4Q	
Renewable	5.9 Q	6.1%
Nonrenewable	91.5 Q	93.9%

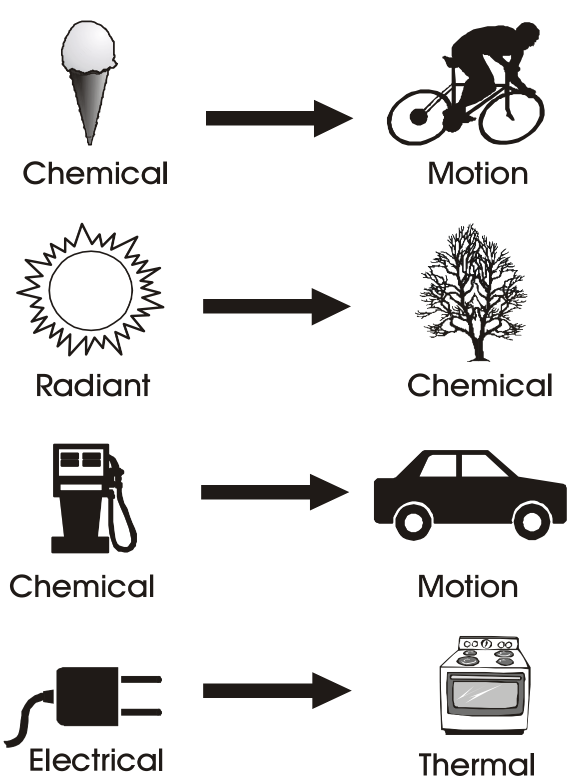
*see MEASURING*energy* on page 10   Q = quads

What Is Energy?

Energy does things for us. It moves cars along the road and boats on the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs and lights our homes at night so we can read a good book.

Energy helps our bodies grow and our minds think. Energy is a changing, doing, moving, working thing.

Energy Transformations



Energy is defined as the ability to produce change or do work, and that work can be divided into several main tasks we easily recognize:

Energy produces light.
Energy produces heat.
Energy produces motion.
Energy produces sound.
Energy produces growth.
Energy powers technology.

There are many forms of energy, but they all fall into two categories– potential or kinetic.

Potential Energy is stored energy and the energy of position—gravitational energy. There are several forms of potential energy, including:

Chemical Energy is energy stored in the the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy.

During photosynthesis, sunlight gives plants the energy they need to build complex chemical compounds. When these compounds are broken, the stored chemical energy is released as heat, light, motion and sound.

Stored Mechanical Energy is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.

Nuclear Energy is energy stored in the nucleus of an atom—the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called **fission**. The sun combines the nuclei of hydrogen atoms into helium atoms in a process called **fusion**.

In both fission and fusion, mass is converted into energy, according to Einstein's Theory, $\mathbf{E = mc^2}$.

Gravitational Energy is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

Kinetic Energy is motion—the motion of waves, electrons, atoms, molecules, substances, and objects.

Electrical Energy is the movement of electrons. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrons moving through a wire is called electricity. Lightning is another example of electrical energy.

Radiant Energy is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays and radio waves. Light is one type of radiant energy. Solar energy is an example of radiant energy.

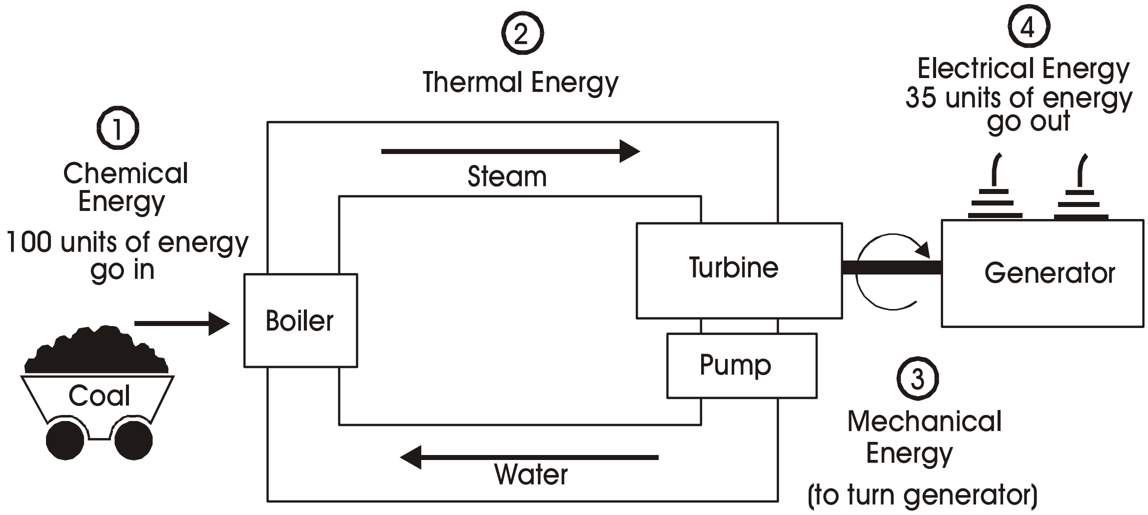
Thermal Energy, or **heat**, is the internal energy in substances—the vibration and movement of atoms and molecules within substances. The faster molecules and atoms vibrate and move within substances, the more energy they possess and the hotter they become. Geothermal energy is an example of thermal energy.

Motion is the movement of objects and substances from one place to another. Objects and substances move when a force is applied according to **Newton's Laws of Motion**. Wind is an example of motion energy.

Sound is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate—the energy is transferred through the substance in a wave.

EFFICIENCY OF POWER PLANTS

Most power plants are about 35% efficient. That means for every 100 units of energy that go into a plant, 65 units are lost as one form of energy is converted to other forms. Thirty-five units are produced to do usable work.



Conservation of Energy

Your parents may tell you to conserve energy. “Turn out the lights,” they say. But, to scientists, conservation of energy means something quite different. The **law of conservation of energy** says energy is neither created nor destroyed.

When we use energy, we do not use it up—we just change its form. That’s really what we mean when we say we are using energy. We change one form of energy into another.

A car engine burns gasoline, converting the chemical energy in the gasoline into mechanical energy that makes the car move. Old-fashioned windmills changed the kinetic energy of the wind into mechanical energy to grind grain. Solar cells change radiant energy into electrical energy.

Energy can change form, but the total quantity of energy in the universe remains the same. The only exception to this law is when a small amount of matter is converted into energy during nuclear fusion and fission.

Energy Efficiency

Energy efficiency is how much useful energy you can get out of a system. In theory, a 100 percent energy-efficient machine would change all of the energy put in it into useful work. Converting one form of energy into another form always involves a loss of usable energy, usually in the form of heat.

In fact, most energy transformations are not very efficient. The human body is no exception.

Your body is like a machine, and the fuel for your “machine” is food. Food gives us the energy to move, breathe, and think. But your body isn’t very efficient at converting food into useful work. Your body is less than five percent efficient most of the time, and rarely better than 15 percent efficient. The rest of the energy is lost as heat. You can really feel the heat when you exercise!

An incandescent lightbulb isn’t efficient either. A lightbulb converts ten percent of the electrical energy into light and the rest (90 percent) is converted into thermal energy (heat). That’s why a lightbulb is so hot to the touch.

Most electric power plants are about 35 percent efficient. It takes three units of fuel to make one unit of electricity. Most of the other energy is lost as waste heat. The heat dissipates into the environment where we can no longer use it as a practical source of energy.

Sources of Energy

People have always used energy to do work for them. Thousands of years ago, cave men burned wood to heat their homes. Later people used the wind to sail ships. A hundred years ago, people used falling water to make electricity.

Today people are using more energy than ever before and our lives are undoubtedly better for it. We live longer, healthier lives. We can travel the world, or at least see it on television.

Before the 1970s, Americans didn’t think about energy very much. It was just there. The energy picture changed in 1973. The **Organization for Petroleum Exporting Countries**, better known as **OPEC**, placed an embargo on the United States and other countries.

The embargo meant OPEC would not sell its oil to the U.S. and our allies. Suddenly, our supply of oil from the Middle East disappeared. The price of oil in the U.S. rose quickly. Long lines formed at gas stations as people waited to fill their tanks with that precious, hard-to-get liquid that they had taken for granted for so many years.

Petroleum is just one of the many different sources of energy we use to do work for us.

U. S. ENERGY CONSUMPTION BY SOURCE

BIOMASS 2.9% *renewable* **Heating, electricity, transportation**	**PETROLEUM** 37.2% *nonrenewable* **Transportation, manufacturing**
HYDROPOWER 2.7% *renewable* **Electricity**	**NATURAL GAS** 23.7% *nonrenewable* **Heating, manufacturing, electricity**
GEOTHERMAL 0.3% *renewable* **Heating, electricity**	**COAL** 22.8% *nonrenewable* **Electricity, manufacturing**
WIND 0.1% *renewable* **Electricity**	U 235 **URANIUM** 8.3% *nonrenewable* **Electricity**
SOLAR & OTHER 0.1% *renewable* **Light, heating, electricity**	**PROPANE** 1.9% *nonrenewable* **Manufacturing, heating**

The ten major energy sources we use today are classified into two broad groups—renewable and nonrenewable.

Nonrenewable energy sources are the kind we use most in the United States. Coal, petroleum, natural gas, propane, and uranium are nonrenewable energy sources. They are used to make electricity, to heat our homes, to move our cars, and to manufacture all sorts of products from candy bars to CDs.

These energy sources are called nonrenewable because they cannot be replaced. Petroleum, for example, was formed millions of years ago from the remains of ancient sea life, so we can't replace our supplies. We could run out of nonrenewable sources some day.

Renewable energy sources include biomass, geothermal, hydropower, solar and wind. They are called renewable energy sources because their supplies are replenished. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

Speaking of electricity, is it a renewable or nonrenewable source of energy? The answer is neither.

Electricity is different from the other energy sources because it is a **secondary** source of energy. That means we have to use another energy source to make it. In the United States, coal is the number one fuel for generating electricity.

Energy Use

Imagine how much energy you use every day. You wake up to an electric alarm clock. You take a shower with water warmed by a hot water heater.

MEASURING*energy*

"You can't compare apples and oranges," the old saying goes. And that holds true for energy sources. Just think. We buy gasoline in gallons, wood in cords, and natural gas in cubic feet. How can we compare them?

With British thermal units, that's how. The heat energy contained in gasoline, wood, or other energy sources can be measured by British thermal units or Btu's.

One Btu is the heat energy needed to raise the temperature of one pound of water one degree Fahrenheit. A single Btu is quite small. A wooden kitchen match, if allowed to burn completely, would give off one Btu of energy. One ounce of gasoline contains almost 1,000 Btu's of energy. Every day the average American uses roughly 889,000 Btu's.

We use the quad to measure very large quantities of energy. A quad is equal to one quadrillion (1,000,000,000,000,000) Btu's. The United States uses about one quad of energy every 3.9 days. In 2001, Americans consumed 97.1 quads of energy, an all-time high.

You listen to music on the radio as you dress. You catch the bus to school. And that's just some of the energy you use to get you through the first part of your day!

Every day, the average American uses about as much energy as is stored in seven gallons of gasoline. That's every person, every day. Over a course of one year, the sum of this energy is equal to about 2,500 gallons of oil. The use of energy is sometimes called **energy consumption**.

Who Uses Energy?

The U.S. Department of Energy uses three categories to classify energy users: residential and commercial, industrial, and transportation. These users are sometimes called the sectors of the economy.

Residential/Commercial

Residences are people's homes. Commercial buildings include office buildings, hospitals, stores, restaurants, and schools. Residential and commercial energy use are lumped together because homes and businesses use energy in the same ways—for heating, air conditioning, water heating, lighting, and operating appliances.

The residential/commercial sector of the economy consumed more energy than either of the other sectors in 2002—38.4 quads (the residential sector consumed 21.0 quads and the commercial sector consumed 17.4 quads).

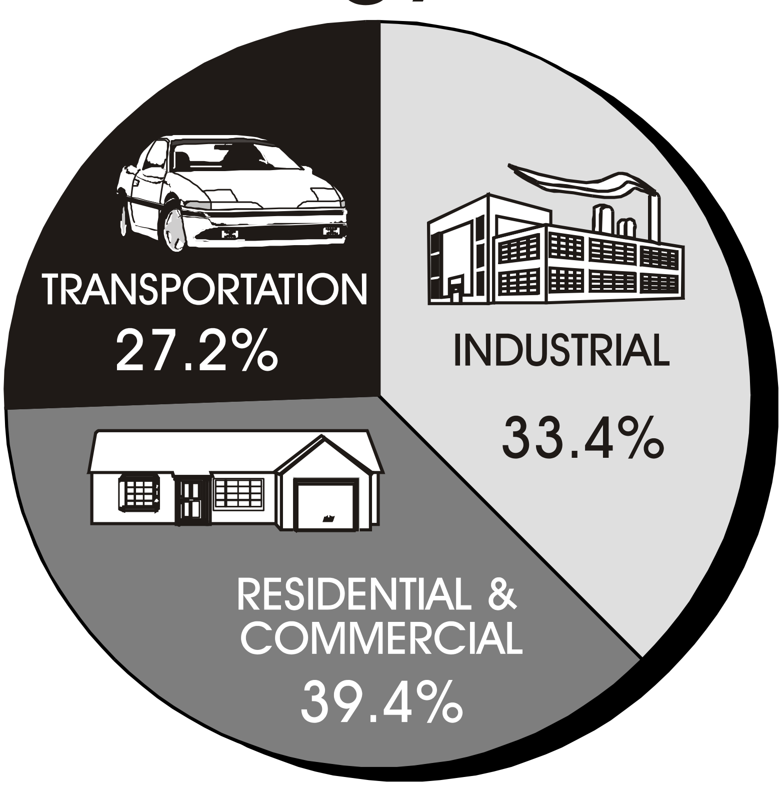
Industrial

The industrial sector includes manufacturing, construction, mining, farming, fishing, and forestry. This sector consumed 32.5 quads of energy in 2002—5.9 quads less than the residential/commercial sector.

Transportation

The transportation sector refers to energy use by cars, buses, trucks, trains, ships, and airplanes. In 2002, the U.S. used large amounts of energy for transportation, 26.5 quads. About 97 percent of this energy was supplied by petroleum products such as gasoline, diesel and jet fuel.

Energy Use



SOURCE: ENERGY INFORMATION ADMINISTRATION

Energy Use and Prices

In 1973, when Americans faced their first oil price shock, people didn't know how the country would react. How would Americans adjust to skyrocketing energy prices? How would manufacturers and industries respond? We didn't know the answers.

Now we know that Americans tend to use less energy when energy prices are high. We have the statistics to prove it.

When energy prices increased sharply in the early 1970s, energy use dropped, creating a gap between actual energy use and how much the experts had thought Americans would be using.

The same thing happened when energy prices shot up again in 1979 and 1980—people used less energy. In 1985, when prices started to drop, energy use began to increase.

We don't want to simplify energy demand too much. The price of energy is not the only factor in the equation. Other factors that affect how much energy we use include the public's concern for the environment and new technologies that can improve the efficiency and performance of automobiles and appliances.

Most energy savings in recent years have come from improved technologies in industry, vehicles, and appliances. Without these energy conservation and efficiency technologies, we would be using much more energy today.

In 2002, the United States used 25–30 percent more energy than it did in the 1970s. That might sound like a lot, but the population increased by about 30 percent and the nation's **gross national product** (the total value of all the goods and services produced by a nation in one year) was 80 percent higher!

If every person consumed energy today at the rate we did in the 1970s, we would be using much more energy than we are today—perhaps as much as double the amount. Energy efficiency technologies have made a huge impact on overall consumption since the energy crisis of 1973.